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Material Offshoring: Alternate Measures

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p	preliminary
r	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
E	use with caution
F	too unreliable to be published
*	significantly different from reference category ($p < 0.05$)

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Table of contents

Abstract **5**

Executive summary **6**

1 Introduction **7**

2 Methodology **8**

2.1 Method 1, standard proportionality approach (includes non-intermediate commodities) 8

2.2 Method 2, proportionality approach (excludes non-intermediate commodities) 9

2.3 Method 3, direct measures of industry imports using the Importer Register 10

2.4 Method 4, direct measures using linked input and import micro databases 10

2.5 Method 5, hybrid measures combining the proportionality input approach and the direct-import approach 11

2.6 Method 6, modified hybrid measure 11

3 Comparison of offshoring measures for goods **11**

4 Conclusion **18**

5 Appendix **20**

5.1 Data linkage of the Annual Survey of Manufacturers and the Importer Register 20

References **21**

Abstract

In order to study the importance of material offshoring (defined in this paper as the use of intermediate imported materials) at the industry level, it is generally assumed that the import share of each input commodity for a particular industry is similar to that for the economy as a whole—because import data tend to be available only for the latter. This is referred to as the proportionality-based measure of offshoring.

Recent advances in administrative trade data permit the development of more industry-specific measures of imports. However, these measures generally capture the agent that engages in importation. These firms may only be performing an intermediation role and may be located in industries (e.g., trade or finance) that differ from the industry of use. This study reports on these more direct measures of industry imports using Canadian micro import data as well as hybrid measures that make use of both input and import information. Estimates from various alternatives are then compared to estimates derived from a survey that asked for information on import intensity as part of a more general investigation of innovation.

Executive summary

Imports of intermediate materials (material offshoring) are an important facet of the production process in Western countries. As a result of a lack of data on imported intermediates by industry, almost all major studies on offshoring have relied on a proxy measure that assumes an industry's import intensity of an input commodity is similar to that for the economy as a whole. This is referred to as the proportionality-based measure of offshoring.

Recent advances in administrative trade data permit the calculation of more direct industry-specific measures of imports. However, these measures capture the agent that engages in importation, who may be an intermediary rather than a final user of the import. More importantly, the importer may be assigned to a different industry than the user. This study reports on these more direct measures of industry imports using Canadian micro data on firm imports. It further proposes a hybrid method that supplements the direct-import approach with a modified proportionality input approach, which is used to re-allocate surplus imports purchased by intermediary industries to other input-using industries. Estimates from these alternative approaches are then compared to estimates derived from a survey that asked manufacturing firms for information on import intensity as part of a more general investigation of innovation.

This study finds that:

- There are large industry differences between the proportionality approach and the direct-import approach at the industry level. In particular, material imports in the Wholesale, Retail, and Finance, Insurance, and Real Estate (FIRE) (head offices) industries are well above their input use when the direct approach is used. These industries probably serve as intermediaries for users in other industries.

- Neither the proportionality approach nor the direct-import approach yield measures that approximate those from the survey across all industries. The proportionality approach generates a good proxy of offshoring for non-durables industries, but yields an overestimate for durables industries. By contrast, the direct-import approach generates a good proxy of offshoring for durables industries, but yields an underestimate for non-durables industries.

- The hybrid method improves measures yielded by the direct-import approach, in the sense that measures move closer to the survey estimates. In particular, when the fact that some commodities imported by intermediaries are not utilized as intermediates is taken into account, the hybrid method yields estimates that are better proxies than all other alternatives for the manufacturing sector in the sense that they more closely approximate the estimates derived from the survey. When actual data on imported-input use by industry are lacking, the hybrid method, which employs both input and import information, may reduce the potential bias that either approach (proportionality input approach and direct-import approach) generates.

1 Introduction

Imports of intermediate materials are an important facet of the production process in Western countries. The Organization for Economic Cooperation and Development (OECD) (2007) reports that more than half (54% in 2003) of world manufactured imports are intermediate goods. In Canada, intermediate-material imports accounted for 53% of total imports in 2002 and grew at an average rate of 5.4% per year between 2002 and 2006. The increasing use of imported materials has generated extensive research and debate, both academically and within the media, on the effects of offshoring on domestic employment and industrial structure.

As a result of a lack of data on imported intermediates by industry, almost all major studies on offshoring have relied on a proxy measure outlined by Feenstra and Hanson (1996, 1999), which makes use of the "proportionality" assumption. An industry's import intensity of a particular commodity is assumed to be the same as the economy-wide import intensity. This assumption has two main shortcomings: it does not draw a distinction between imports that are used as intermediate goods or as final goods; and it makes no allowance for differences in import intensity across industries. Industry differences arise only from differences across industries in the composition of commodities used.

Recent advances in administrative trade data permit more industry-specific measures of imports that allow changes in offshoring intensity to be calculated over time and across a wide range of industries. However, these measures capture the agent that engages in importation, which may be an intermediary rather than a final user of the import. This paper reports on these more direct measures of industry imports using Canadian micro data on firm imports as well as on hybrid measures that combine both the proportionality assumption and direct-import information. The paper then compares them to import ratios that make use of the proportionality assumption. Finally, it compares both to estimates derived from a 2004 survey that asks manufactures to estimate the proportion of their inputs coming from imports. The latter provide a more direct measure that unfortunately is limited to one year, but that nevertheless sheds light on the accuracy of alternate estimates of the intensity of offshoring.

Being able to derive accurate measures of import use is important since studies of offshoring rely on such measures. The OECD and the World Trade Organization (WTO) are constructing world input-output tables to study the impact of globalization and are making use of the proportionality assumption to measure, *mutatis mutandis*, the impact of global value chains.

To date, only two studies have assessed the accuracy of the proxy measure derived from the proportionality assumption. Winkler and Milberg (2009) compared a direct measure of import-input use by German industry to the proxy measure derived from the standard proportionality assumption, and found that the proxy-based measure differed significantly from the direct measure. Feenstra and Jensen (2012) linked firms' import data with production data in an effort to use information collected in the U.S. Census of Manufactures regarding materials employed by manufacturing establishments in order to allocate imported intermediates to industries. They find a correlation of 0.68 (un-weighted) and 0.87 (value-weighted) between the offshoring shares made with and without the proportionality assumption.

The goal of this study is two-fold. First, the study proposes alternate ways of constructing offshoring measures for materials and demonstrates how these differ conceptually from the standard proportionality method. Second, it uses both Canadian Input-Output tables and micro import data to compare the results produced under the alternative measures—the standard proportionality assumption, the direct-import approach, and a hybrid approach that supplements direct-import data with input information—against a direct measure of offshoring derived from a

sample of firms taken from the 2005 Survey of Innovation, where Canadian manufacturing firms reported an estimate of the percentage of total material expenditures imported in 2004.

Section 2 outlines the methodology used to construct the various offshoring measures. Results are presented in Section 3. Section 4 concludes.

2 Methodology

Offshoring is defined as the import share of total expenditure on raw material and intermediate inputs. This section outlines the six different approaches used in this study to measure offshoring: (1) the standard approach, which is based on the proportionality assumption and includes all commodities; (2) the modified proportionality approach, which excludes non-intermediate commodities; (3) the direct micro import approach, which makes use of import information from the Importer Register; (4) the micro linked approach, which links input and import data at the firm level; (5) a hybrid approach, which supplements the direct-import approach with input information in order to distribute the imports of intermediary industries in excess of their inputs to other industries; and (6) a modified hybrid approach, which recognizes that some commodities imported by intermediary industries may be inappropriately classified as intermediates.

2.1 Method 1, standard proportionality approach (includes non-intermediate commodities)

The standard proxy measure of materials offshoring ($O_i^{Method1}$) for industry *i* is typically constructed using total imports of commodities defined as good as opposed to services and material inputs per industry derived from input-output tables. Offshoring measures at the industry level are weighted averages of the commodity import intensity for the entire economy where the weights applied to these intensities are taken from the importance of inputs in a particular industry. The proxy measure is defined as follows (for abbreviation, the time subscripts are omitted):

$$O_i^{Method1} = \frac{\sum_j INP_{ij} \times (\frac{IMP_j}{CON_j})}{\sum_j INP_{ij}} = \sum_j \frac{INP_{ij}}{\sum_j INP_{ij}} \times (\frac{IMP_j}{CON_j}), \quad (1)$$

where IMP_j and CON_j are total import and total domestic consumption, respectively, of commodity *j*, and INP_{ij} is the input of commodity *j* for industry *i*. In this study, commodity *j* is defined by a classification used in the Canadian Input-Output tables—the *IOCCX* level—which contains a total of 293 commodity groups.[1]

1. The *IOCCX* level of commodity classification is defined at a slightly more aggregate level than the *W* level used in the Input-Output tables of Statistics Canada.

2.2 Method 2, proportionality approach (excludes non-intermediate commodities)

One limitation of Method 1 is that the import intensity for commodity *j* in equation (1) that is available in standard input-output tables includes both intermediates and final goods. The ratios are actually not calculated against inputs in an industry; they are calculated relative to final demand. Each commodity *j* typically consists of a set of more detailed products, some of which are used as intermediates, some for investment, some for final consumption, and some for both intermediate and final demand. Offshoring is a concept that refers to the sourcing of intermediate inputs abroad. Final products therefore need to be removed from offshoring measures.

To evaluate the extent of the bias arising from the inclusion of non-intermediate goods In Method 1, the proxy measure ($O_i^{Method2}$) is modified to include only intermediate imports and to be calculated relative to inputs of commodities used at the industry level. The new measure is written as:

$$O_i^{Method2} = \frac{\sum_j INP_{ij} \times (\frac{IMP'_j}{INP_j})}{\sum_j INP_{ij}} = \sum_j \frac{INP_{ij}}{\sum_j INP_{ij}} \times (\frac{IMP'_j}{INP_j}), \quad (2)$$

where IMP'_j is the total intermediate imports within commodity group *j*. To derive IMP'_j, three steps are followed. First, a commodity concordance between the input-output and the Importer Register is established. The Canadian Input-Output tables contain 293 commodity groups at the *IOCCX* aggregation level, while the Importer Register has more than 19,000 commodities classified at the 10-digit Harmonized System (HS10) level. Each input-output commodity group *j* is linked to a set of corresponding HS10 imported products. Second, to identify which imported HS10 products are intermediates, the United Nations' (UN) Broad Economic Categories (BEC), which groups HS6 commodities (more aggregate level than HS10, containing around 5000 commodities) into intermediates and non-intermediates, is used. Third, total intermediate imports within commodity group *j* (IMP'_j) are benchmarked to total imports of commodity *j* in the input-output table, by first estimating the proportion of intermediates in total imports within each commodity *j* from the Importer Register and then applying the proportion to the total imports of commodity *j* in the input-output table. Equation (2) can also be rewritten as:

$$O_i^{Method2} = \frac{\sum_j \frac{INP_{ij}}{\sum_i INP_{ij}} \times IMP'_j}{\sum_j INP_{ij}}. \quad (3)$$

This formulation then distributes total intermediate imports of commodity *j* (IMP'_j) to an industry according to its share of input use of that commodity ($\frac{INP_{ij}}{\sum_i INP_{ij}}$).

2.3 Method 3, direct measures of industry imports using the Importer Register

A potential limitation of the standard proportionality approach is the assumption that the import intensity of particular commodities is constant across industries. Method 3 attempts to overcome this deficiency by using direct measures of imports by industry derived from the Importer Register. This is done by taking the firm identifier that all importers provide to the customs authorities and assigning the imports to the industry of the firm doing the importing.

Since the Importer Register may not be complete and may not correspond exactly to total commodity imports in the input-output system, the direct measure of industry intermediate imports from the Importer Register is adjusted so that for each commodity *j* the total intermediate imports across all industries equal the benchmark total of intermediate imports (IMP'_j) in the input-output system derived under Method 2. The direct measure of offshoring ($O_i^{Method3}$) is defined as follows:

$$O_i^{Method3} = \frac{\sum_j IMP'_{ij}}{\sum_j INP_{ij}} = \frac{\sum_j \frac{IMP_{ij}}{\sum_i IMP_{ij}} \times IMP'_j}{\sum_j INP_{ij}}, \tag{4}$$

where IMP'_{ij} is the adjusted direct measure of industry *i*'s total intermediate imports of commodity *j*, and IMP_{ij} is the total intermediate imports of commodity *j* for industry *i* calculated directly from the Importer Register.

2.4 Method 4, direct measures using linked input and import micro databases

The fourth method generates direct measures by using import data directly linked to Annual Survey of Manufactures (ASM) data. This approach does not use the North American Industry Classification System (NAICS) industry code, which is available on the Importer Register, and links the data directly to obtain an industry identifier for the import data (see Appendix). The linked dataset provides firm-level information on the value of total material costs derived from the ASM and on the value of total intermediate imports from the Importer Register. Together, the two types of information can be used to calculate an offshoring ratio for each firm in the ASM.

The linked firms are typically large enterprises in the manufacturing sector. Over the 2002-to-2006 period, around 52% of firms in the ASM are linked to the Importer Register. These firms account for an average of 76% of total manufacturing shipments. For the purposes of this study, it was assumed that unlinked ASM firms are not importers.

An industry *i*'s offshoring is defined as follows:

$$O_i^{Method4} = \frac{\sum_{f \in i} IMP_{f,j}}{\sum_{f \in i} TMAT_{f,j}}, \tag{5}$$

where $TMAT_{f,j}$ is total material costs and $IMP_{f,j}$ is total intermediate imports of commodity *j* for firm *f*, from the ASM and the Importer Register, respectively. This direct measure using linked production and import micro data is conceptually similar to the measure employed in Method 3.

2.5 Method 5, hybrid measures combining the proportionality input approach and the direct-import approach

Using import data creates a problem if the firm that reports imports is not actually using the product and is in a separate industry from the actual user. The importer may serve as an intermediary (such as the wholesale and retail industries, or the holding companies and head offices that are classified under the Finance and Insurance, Real Estate and Rental and Leasing, Management of Companies and Enterprises industries). To address this issue, Method 3 is modified by assuming that the surplus of imports in excess of inputs used in an industry, as are reported by the Input-Output tables, are consumed in other industries—in proportion to the consumption of the intermediate inputs used elsewhere. In effect, this variant combines the information available on the industry of the firm doing the importing and supplements it with the direct proportionality assumption for imports that are purchased by intermediaries for imports that are in excess of their intermediate consumption.

2.6 Method 6, modified hybrid measure

An additional problem with Method 5 is the commodity classification used. Even though non-intermediate products were excluded in Methods 2, 3, 4, and 5 under the UN BEC classification system, the classification of some commodities remains problematic. Engines, for example, are classified as intermediate goods under the UN BEC system. This is most likely to be true if they are imported and utilized by Transportation Equipment industries. However, they become investment goods if utilized by other industries, such as Textile industries, and become final consumption goods if used by consumers. Other similar products include Fabricated Metal Products, Machinery, Motor Vehicles, Other Transportation Equipment and Parts, Electrical, Electronic, and Communication Products, Mineral Fuels, and Hosiery, Clothing, and Accessories.

To address this issue, this study assumes that the above-mentioned commodities imported by wholesale and retail industries are not used as intermediates. As a result, any surplus of these commodities in the wholesale and retail industries are not re-allocated to other industries as intermediate inputs.

3 Comparison of offshoring measures for goods

Table 1 reports aggregate estimates using the different measures of offshoring for the Canadian business sector between 2002 and 2006. The overall estimates produced using Methods 1 and 2 are quite similar. The effect of including non-intermediate goods in the standard proportionality approach is quite small for the entire business sector. By construction, the proportion of imported intermediates for the business sector as a whole is the same under Methods 2, 3, and 5 (Table 1). Method 6 yields a lower estimate of offshoring because certain commodities imported by wholesale and retail trade as non-intermediate products are excluded. All of the estimates are quite stable over time.

Table 1

Proportion of imported intermediates, Canadian business sector

	Proportionality input approach		Direct-import approach		Hybrid of proportionality input and direct-import approaches	
	Method 1 (including non-intermediate goods)	Method 2 (excluding non-intermediate goods)	Method 3 Micro import data linked to Input-Output input data	Method 4 Micro import data linked to micro manufacturing data from the Annual Survey of Manufacturers	Method 5 Uses proportionality to distribute all excess imports to all industries	Method 6[1] Same as Method 5, but excludes certain excess imports from wholesale and retail
	ratio					
Year						
2002	0.38	0.34	0.34	...	0.34	0.30
2003	0.35	0.32	0.32	...	0.32	0.28
2004	0.35	0.33	0.33	...	0.33	0.28
2005	0.35	0.33	0.33	...	0.33	0.28
2006	0.35	0.33	0.33	...	0.33	0.28
Average over all years	0.35	0.33	0.33	...	0.33	0.29

1. The assumption is that certain commodities imported by wholesale and retail industries are not used as intermediaries. Such commodities include Mineral Fuels, and Hosiery, Clothing, and Accessories, which are most likely to be used as consumption goods, and Fabricated Metal Products, Machinery, Motor Vehicles, Other Transportation Equipment and Parts, and Electrical, Electronic, and Communication Products, which are most likely to be used as investment goods.

Sources: Statistics Canada, Canadian Input-Output tables, Importer Register, and Annual Survey of Manufactures.

The difference between Methods 2 and 3 occurs at the industry level (Table 2). Method 2 adopts the traditional proportionality assumption, which distributes total intermediate imports to industries according to the input use of particular commodities (Equation [3], while Method 3 distributes total intermediate imports to industries according to the value of imports (Equation [4]). The two methods yield very different industry estimates. Industries such as Utilities, Wholesale, Warehousing, Retail, Professional, Scientific, and Technical Services, Administrative and Support Services, Educational Services, and Finance and Insurance, Real Estate and Rental and Leasing, Management of Companies and Enterprises have a much higher proportion of imported intermediates under Method 3 (using import information) than under Method 2 (using input information). It is likely that these industries serve as intermediaries for imports that are then sold to other industries that make use of these imports.

Under the UN BEC classification of intermediate commodities, Wholesale, Retail, and FIRE (head offices are classified under FIRE) industries import around 22%, 3%, and 12% of total intermediate materials, respectively. Mineral Fuels, Fabricated Metal Products, Machinery, Motor Vehicles, Other Transportation Equipment and Parts, and Electrical, Electronic, and Communication Products are among the major imported items, accounting for around 50% of total imports in the Wholesale and FIRE industries. Mineral Fuels account for 69% of total intermediate imports in the retail industry.[2]

The hybrid approaches (Method 5 and Method 6), which use both the industry direct-import information as well as the input information to distribute any surplus imports to input-use industries, yield offshoring measures that lie between the proportionality input approach (Method 2) and the direct-import approach (Method 3). Measures from Method 6 are slightly lower than those under Method 5 since it is assumed for the purposes of this study that certain commodities imported by intermediaries, such as wholesale and retail, are not used as intermediates and therefore that any surplus imports in the two industries are not re-distributed (Table 2).

2. In the Utilities industry, 92% of imports are Mineral Fuels. The total material imports in the Warehousing and Education sectors are small, accounting for less than 0.5% of total material imports.

Table 2
Proportion of imported intermediates, Canadian business sector by industry, 2004

	Proportionality input approach		Direct-import approach		Hybrid of proportionality input and direct-import approaches	
	Method 1 (including non-intermediate goods)	Method 2 (excluding non-intermediate goods)	Method 3 Micro import data linked to Input-Output input data	Method 4 Micro import data linked to micro manufacturing data from the Annual Survey of Manufacturers	Method 5 Uses proportionality to distribute all excess imports to all industries	Method 6[1] Same as Method 5, but excludes certain excess imports from wholesale and retail
	ratio					
Total business sector (average over all years from Table 1)	0.35	0.33	0.33	...	0.33	0.28
Industry name (NAICS code)						
Agriculture, Forestry, Fishing and Hunting (11)	0.16	0.16	0.03	...	0.11	0.10
Mining, Quarrying, and Oil and Gas Extraction (21)	0.32	0.29	0.13	...	0.23	0.15
Utilities (22)	0.34	0.28	1.15	...	0.44	0.42
Construction (23)	0.25	0.23	0.02	...	0.18	0.13
Manufacturing (3A)	0.41	0.40	0.25	0.25	0.41	0.35
Wholesale (41)	0.15	0.13	5.38	...	0.35	0.35
Transportation (48)	0.24	0.17	0.09	...	0.13	0.11
Warehousing (49)	0.13	0.10	0.93	...	0.13	0.12
Retail Trade (4A)	0.12	0.09	0.96	...	0.11	0.10
Information and Cultural Industries (51)	0.47	0.74	0.09	...	0.75	0.64
Professional, Scientific, and Technical Services (54)	0.25	0.23	1.53	...	0.31	0.31
Administrative and Support and Waste Management and Remediation Services (56)	0.16	0.13	0.61	...	0.16	0.14
Finance and Insurance, Real Estate and Rental and Leasing, Management of Companies and Enterprises (5A)	0.07	0.06	2.62	...	0.02	0.02
Educational Services (61)	0.05	0.04	4.89	...	0.01	0.00
Health Care and Social Assistance (62)	0.42	0.16	0.04	...	0.13	0.13
Arts, Entertainment, and Recreation (71)	0.17	0.06	0.04	...	0.05	0.05
Accommodation and Food Services (72)	0.14	0.05	0.19	...	0.03	0.03
Other Services (except Public Administration) (81)	0.19	0.13	0.41	...	0.18	0.17

1. The assumption is that certain commodities imported by wholesale and retail industries are not used as intermediaries. Such commodities include Mineral Fuels, and Hosiery, Clothing, and Accessories, which are most likely to be used as consumption goods, and Fabricated Metal Products, Machinery, Motor Vehicles, Other Transportation Equipment and Parts, and Electrical, Electronic, and Communication Products, which are most likely to be used as investment goods. The term NAICS refers to North American Industry Classification System.

Sources: Statistics Canada, Canadian Input-Output tables, Importer Register, and Annual Survey of Manufacturers.

The six methods used in this study to measure import utilization in the production process all employ indirect methods, and produce different estimates at the industry level. To provide a source of triangulation, this study makes use of data from Statistics Canada's 2005 Survey of Innovation. The survey provides direct measures for manufacturing by asking plants in the manufacturing and logging sector for the percentage of total expenditures on raw materials and components from different geographical locations (Canada, United States, Mexico, Europe, Asia Pacific, and all other countries) for the year 2004. The point estimates will have confidence intervals that arise both from non-sampling error (the question is inherently difficult to answer by respondents) and from sampling error (not all firms were asked the question and not all answered it).

The six alternative measures of offshoring are compared to those derived from the Survey of Innovation for NAICS three-digit Canadian manufacturing industries in Table 3. Three observations are noteworthy. First, for the non-durables sector as a whole, offshoring estimates using the proportionality assumption under Methods 1 and 2 (0.31 and 0.27, respectively) are quite close to the survey point estimates of 0.32. Methods 3 and 4, which directly use the import information, yield a much smaller value (0.15 and 0.17, respectively). This would occur because the non-durables sector uses more intermediate imports than it directly purchases from abroad and if it relies on intermediate purchases of imports from other industries such as wholesale and retail trade.

Table 3
Proportion of imported intermediates, Canadian manufacturing, 2004

Industry name (NAICS code)	Estimates from Survey of Innovation 2005			Proportionality- input approach		Direct-import approach		Hybrid Approach	
	Mean	Confidence Interval		Method 1 (including non-intermediate goods)	Method 2 (excluding non-intermediate goods)	Method 3 (Micro import data linked to Input-Output input data)	Method 4 (Micro import data linked to micro manufacturing data from the Annual Survey of Manufacturers)	Method 5 (Uses proportionality to distribute all excess imports to all industries)	Method 6 Same as method 5, but exclude certain excess imports from wholesale and retail
		Lower bound	Upper bound						
	ratio								
Manufacturing	0.29	0.28	0.29	0.41	0.40	0.25	0.25	0.41	0.35
Non-durable sector	0.32	0.30	0.33	0.31	0.27	0.15	0.17	0.27	0.23
Food, beverage and tobacco products (311-312)	0.16	0.14	0.18	0.15	0.10	0.05	0.05	0.09	0.09
Textile mills and texitile product mills (313-314)	0.53	0.49	0.58	0.58	0.54	0.39	0.49	0.60	0.52
Clothing, leather and allied product (315-316)	0.44	0.40	0.47	0.57	0.73	0.27	0.14	0.67	0.49
Paper (322)	0.32	0.28	0.35	0.20	0.19	0.12	0.12	0.19	0.19
Printing and related support activities (323)	0.26	0.22	0.29	0.33	0.32	0.11	0.08	0.24	0.24
Petroleum and Coal product (324)	0.24	0.17	0.31	0.42	0.41	0.16	0.15	0.42	0.28
Chemical (325)	0.40	0.36	0.43	0.31	0.26	0.20	0.34	0.29	0.28
Plastic and rubber products (326)	0.43	0.40	0.46	0.54	0.43	0.30	0.29	0.42	0.41
Durable sector	0.27	0.26	0.28	0.50	0.50	0.34	0.32	0.52	0.46
Wood product (321)	0.11	0.09	0.13	0.12	0.11	0.08	0.07	0.12	0.12
Non-metallic mineral product (327)	0.23	0.18	0.27	0.22	0.24	0.17	0.18	0.24	0.23
Primary metal (331)	0.30	0.26	0.35	0.40	0.41	0.19	0.41	0.39	0.37
Fabricated metal product (332)	0.24	0.22	0.26	0.36	0.34	0.29	0.26	0.38	0.29
Machinery (333)	0.32	0.29	0.35	0.51	0.46	0.17	0.24	0.44	0.32
Computer and electronic product (334)	0.53	0.50	0.57	0.82	0.82	0.32	0.16	0.81	0.59
Electrical equipment, appliance and component (335)	0.42	0.37	0.47	0.53	0.48	0.24	0.28	0.51	0.41
Transportation equipment (336)	0.41	0.37	0.45	0.60	0.63	0.51	0.52	0.67	0.61
Furniture and related product (337)	0.18	0.15	0.20	0.37	0.31	0.14	0.08	0.29	0.24
Miscellaneous (339)	0.31	0.27	0.34	0.69	0.63	0.40	0.27	0.77	0.74

Sources: Statistics Canada, Canadian Input-Output tables, Import Register, Annual Survey of Manufacturers and 2005 Survey of Innovation.

Table 4
Tests for the differences between alternate measures and survey estimates, Canadian manufacturing, 2004

	Proportionality- input approach against Survey estimates		Direct-import approach against survey estimates		Hybrid Approach against survey estimates	
	Method 1 (including non-intermediate goods)	Method 2 (excluding non-intermediate goods)	Method 3 (Micro import data linked to Input-Output input data)	Method 4 (Micro import data linked to micro manufacturing data from the Annual Survey of Manufacturers)	Method 5 (Uses proportionality to distribute all excess imports to all industries)	Method 6 Same as method 5, but exclude certain excess imports from wholesale and retail
	test probability					
Probability value for the student's t-test for mean differences						
Manufacturing	0.00 *	0.01 *	0.00 *	0.00 *	0.01 *	0.27
Non-durable sector	0.31	0.62	0.00 *	0.00 *	0.69	0.19
Durable sector	0.00 *	0.00 *	0.06	0.11	0.01 *	0.11
Probability value for the sign test for median differences						
Manufacturing	0.03 *	0.01 *	0.01 *	0.01 *	0.10	0.48
Non-durable sector	0.73	0.73	0.01 *	0.01 *	0.73	0.29
Durable sector	0.02 *	0.00 *	0.11	0.11	0.00 *	0.02 *
Probability value for the signed rank test for median differences						
Manufacturing	0.00 *	0.01 *	0.00 *	0.00 *	0.02 *	0.44
Non-durable sector	0.38	0.74	0.01 *	0.01 *	1.00	0.25
Durable sector	0.00 *	0.00 *	0.08	0.06	0.00 *	0.01 *

Note: Asterisk (*) indicates that the null hypothesis of no differences between alternative methods and survey estimates is statistically rejected at 5% level or better.
Sources: Statistics Canada, Canadian Input-Output tables, Import Register, Annual Survey of Manufacturers and 2005 Survey of Innovation

Second, for the durables sector as a whole, offshoring estimates using the proportionality assumption under Methods 1 and 2 (0.50) are higher than the survey point estimates of 0.27. Methods 3 and 4, which directly use the import information, yield measures a bit closer (0.34 and 0.32, respectively) to the survey estimates. This relationship would arise if the durables sector directly imports a larger proportion of its intermediate inputs used in production without going through intermediaries. It may be that the durable-goods sector is more capital- and knowledge-intensive and that intermediate goods in this sector are more sector-specific and require greater control over the import stream.

Third, the hybrid estimates as a whole for Methods 5 and 6 are higher than for Methods 3 and 4 and closer to the survey point estimates than those under the pure direct-import approach (Method 3) since surplus imports from other industries are re-allocated to input-using industries. In particular, Method 6, which takes into account that some commodities imported by intermediary industries may not be used as intermediates, yields estimates within the survey confidence intervals for 44% of 18 NAICS three-digit manufacturing industries. This occurs in less than 22% of industries under either the standard proportionality input approach or the direct import approach.

These observations are reinforced by non-parametric tests, which examine whether estimates from the six methods are in general significantly different from survey estimates. The null hypothesis is that there are no significant differences in mean values under the t-test and in median values under the sign and signed-rank tests. Table 4 shows that: (1) for industry estimates in the manufacturing sector as a whole, the null is rejected for all methods except Method 6 under the t-test and signed-rank test. Method 6 yields industry estimates that are on the whole not significantly different from survey estimates; and (2) the estimates from the proportionality approach are not significantly different from survey estimates for industries in the non-durable sector, while the estimates from the direct-import approach are not significantly different from survey estimates for industries in the durable sector.

4 Conclusion

The proportionality assumption has been widely adopted in order to construct a proxy measure of material offshoring. This paper assesses the validity of that assumption.

The paper first proposes an alternative proxy measure that still makes use of the proportionality assumption but focuses only on intermediate goods. It finds that the difference between the standard proxy measure (which includes non-intermediate final goods) and the alternative proxy measure (which excludes non-intermediate final goods) within the proportionality framework is small.

The paper then proposes offshoring measures that make use of firms' direct-import values taken from the Importer Register. It finds large industry differences between the proportionality approach and the direct-import approach: the former uses industries' input patterns to allocate total intermediate imports, while the latter uses industries' import patterns to allocate total intermediate imports. In particular, the paper finds that material imports in the Wholesale, Retail, and FIRE (head offices) industries are well above their input use. These industries may serve as intermediaries, purchasing imports and reselling them to firms in other industries. Their importance is sizable, accounting for 22%, 3%, and 12% of total material imports, respectively.

Comparisons of the estimates derived from the two approaches are made to a direct measure derived from Statistics Canada's 2005 Survey of Innovation, where Canadian manufacturing firms report their estimated percentage of intermediate material import use. These comparisons show that neither the proportionality approach nor the direct-import approach corresponds to the survey results. The proportionality approach generates an estimate of offshoring for non-

durables industries that roughly corresponds to the survey estimate, but yields an overestimate for durables industries. By contrast, the direct-import approach generates a close estimate to the survey for durables industries, but yields an underestimate for non-durables industries.

Hybrid measures that make use of both the proportionality assumption from the Input-Output tables and a measure of direct imports obtained from the Importer Register improves the estimates yielded by the direct-import approach, in the sense that measures move closer to the survey estimates. In particular, when the paper takes into account that some commodities imported by intermediaries may not be used as intermediates in production, the hybrid method yields estimates that are much better proxies than all other alternatives for many of the manufacturing industries and for the manufacturing sector as a whole.

In conclusion, the paper shows that the proportionality input approach and the direct-import approach often yield quite different measures of offshoring. Estimates using both the input and import information (estimates that take into account intermediary industries and commodity usage) provide better proxies. When actual data on imported-input use by industry is lacking, the hybrid method, which employs both input and import information, may reduce the potential bias inherent in both the proportionality input approach and the direct-import method.

5 Appendix

5.1 Data linkage of the Annual Survey of Manufacturers and the Importer Register

The Annual Survey of Manufactures (ASM) and the Importer Register are linked at the enterprise level each year. The statistical unit of measure in the import/export database is the establishment. An establishment number is obtained by linking import/export data to the Business Register either through a business number (BN) or through a probabilistic location match. Also, to deal with the issue of changing structures of enterprises, such as those resulting from mergers, takeovers, or re-organization, the import/export database allocates the most recent structure (enterprise code) to earlier periods.

For the results reported here, the ASM and the Importer Register are linked at the enterprise level by means of the following steps. First, location identifiers through the Business Register are obtained for each establishment in the Importer Register; these are then linked to the location identifiers in the ASM. Second, the ASM and the Importer Register are linked by using directly the establishment codes in the two databases. Third, cross-sectional enterprise identifiers are obtained for each establishment in the Importer Register through the Business Register and the PAF-NIP (a special file that creates a one-to-one linkage between enterprise and BN, mainly for small enterprises) and are linked to the enterprise codes in the ASM. The data linked through the three identifiers (location, establishment, enterprise) are combined in order to obtain the final linked data at the enterprise level.

The study experiments with an alternative linkage method. It involves the following: (1) Creating a list of BNs for each ASM enterprise for each year, first by using the special PAF-NIP file, (mainly for small enterprises), and then by obtaining BNs for the remaining unlinked ASM enterprises through the Business Register; (2) Once the above concordance has been established between the BN and the ASM enterprise, an ASM enterprise identifier is attached to each corresponding BN in the Importer Register; (3) The ASM enterprise identifier is then used to get the first linked file of ASM-Import; (4) For any unlinked ASM enterprise, the two databases are further merged by means of the existing enterprise identifiers in the files. This improves the linkage rate slightly.

The results from the above two linking methods are very similar, with the first one (the linked data used in this study) yielding slightly higher linkage rates.

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